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Self-Priming Orthodontic Adhesive (SPA)- A Review

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Abstract

In the recent era, orthodontic adhesives have evolved improving the bonding process and has seen significant advancements over time. Yet, adhesive failures continue to occur. The bond strength between the enamel and the orthodontic brackets can be influenced by a variety of conditions. Saliva, blood, gingival fluid, and water are the most common moisture contaminants that greatly impair the bond strength and are believed to be the main cause of bond failure with composite resin. Two crucial points in the bonding process where enamel surface contamination can happen are: 1) Following the etching of the tooth surface and 2) Immediately following the primer application. A smear layer would invariably appear if contamination occurred before priming. In seconds, the etched surface is covered by this layer, which primarily consists of proteins. Thus, porosities of etched enamel surface are contaminated which hinders the resin's ability to penetrate the enamel surface creating resin tags that are less in number and whose lengths are short. With the introduction of each generation, the bonding steps were combined thereby minimizing the time consumption and preventing moisture contamination during bonding. Self-priming orthodontic Adhesive (SPA) incorporated primer into adhesive thus combining the bonding steps and shortening the duration of bonding and enhancing the treatment outcome. In this review we discuss the effectiveness and bond strength of self-priming orthodontic adhesives.

Keywords: adhesive, bond strength, self-priming, orthodontics, bonding

Full length Review Article **Corresponding Author*, e-mail: ashu.anjana04@gmail.com

1. Introduction

Direct bonding technique was introduced by Newman in 1965 by effective clinical application of epoxy resin for bonding. Subsequent advancements in the adhesive formulation and bracket design made the direct bonding technique a virtually essential element of orthodontic therapy [1]. The steps in direct bonding technique evolved through the development of various generations of orthodontic adhesives [2]. Fourth generation adhesive required three steps like etching, primer application and resin placement [3]. Moisture contamination can occur at two crucial points either after enamel surface etching or after primer application. Contamination lowers the surface energy of the etched enamel surface and makes it less favorable for bonding. It also leads to smear layer formation which impairs the resin penetration. To overcome this limitation, the next generation adhesives were introduced which simplified the bonding process by reducing the number of steps and eliminating the moisture contamination and reducing the bonding time [4]. Thus subsequent generations were developed involving 2 component system and later 1 component universal system [3]. The bond strength of an orthodontic adhesive should be adequate enough to withstand the masticatory forces and stresses produced by archwires. Furthermore, the bonding of the adhesive should occur in such a way that would avoid the enamel surface damage while debonding [5]. A newer self

priming adhesive was introduced where primer is incorporated into the adhesive which doesn't require separate application of primer thereby preventing moisture contamination and reducing the chair time. The purpose of this article is to review the efficacy of self-priming adhesive used for orthodontic bonding.

1.1 Function of primer:

Primer is an unfilled resin which is of low viscosity containing triethylene glycol dimethacrylate (TEGDMA) and bisphenol A diglycidyl ether methacrylate (BIS-GMA). The function of primer includes penetration into the etched enamel surface and wet the porous enamel surface to enhance the adhesion and protects the etched enamel surface from demineralisation thereby increasing the bond strength and reducing the marginal leakage [6]. But it has been found that bonding without primer application has lowered the potential risk of occupational exposure to its unpolymerized resin and elimination of a step had reduced the total bonding time reducing moisture contamination [7].

1.2 W*ith primer vs. without primer:*

According to O'Brein et.al, shear bond strength comparison between two groups: with primer and without primer application showed clinically sufficient bond strength for both the groups but the primer group showed higher bond strength compared to the other groups. When primer was used, there was improved penetration into the retentive pits and less air inclusions [8]. In contrast, Tang A et.al performed a study comparing the bond strength of Transbond XT and Phase II adhesive with primer (control group) and without primer (test group) and the results showed increased bond strength without primer use in Transbond XT and with primer in Phase II adhesive group. Scanning electron microscopy showed well formed resin tags with better penetration into peripheral sheaths and cores of etched enamel surface in control (with primer) group while only solid amorphous surfaces were seen in test (without primer) group. The control group with primer had 37.5% of adhesion failure at composite bracket interfaces depicting entire adhesive left on tooth surface showing higher ARI scores making clean up procedure difficult while in test group without primer 62.5% had no adhesive left on tooth surface after debonding [9]. Nandhra S et.al conducted an invivo study on comparison of bond up time, bracket failure rate, ARI scores for a period of 12 months between bonding with primer and without primer. The results obtained were: bond up time difference per bracket between two groups was 4 seconds with less time taken by bonding without primer. Bracket failure rate was higher in without primer group (15.8%) compared to primer group (11.1%). Failure occurred with low ARI score of 0 in without primer group indicating no composite left in tooth surface reducing the time for cleaning the residual composite after debonding [10].

1.3 *Composition of self-priming orthodontic adhesive:*

1.3.1 GC Ortho Connect:

Manufactured by: GC EUROPE N.V., Belgium; GC Orthodontics, Breckerfeld, Germany
Composition:
Resin material: Bis EMA Dimethacrylate(10-30%), urethane dimethacrylate (10-30%), Phosphoric ester monomer (1-5%)

Filler: Ba Glass filler, Silicon dioxide, Silica tine particle (38%). Additional components: Photoinitiator, Fluorescent agent

1.4.2 Biofix:

Manufactured by: Biodinamica Dental Products LDA, Portugal

Composition:
Resin material: Biphenyl A glicidilmethecrylate (34,78%), dimethacrylate urethane ethylene

Filler: Inorganic filler (41- 52%)
Additional components: Titanium dioxide, sodium fluoride, and catalyst [11].

1.4.3 Orthocem:

Manufactured by: FGM Produtos Odontológicos LDA, Brasil

Composition:
Resin material: Bisphenol A diglycidyl ether methacrylate (Bis-GMA)(25–35 wt%), Triethylene glicol dimethacrylate (TEGDMA)(10–15 wt%), Methacrylated phosphate monomer(>2 wt%)

Filler: Silane treated silicon dioxide (45-60%)
Additional components: Camphorquinone (<1 wt%), Sodium fluoride (>1 wt%)

1.4.4 Heliosit:

Manufactured by: Ivoclar Vivadent

Composition:
Resin material: Bis-GMA (50-100%), UDMA (10-25%) and Deca Methyl endi methacrylate (10-25%) [12].

Filler: Highly dispersed silicon dioxide (14 wt%)
Additional components: Catalysts and stabilizers (1 wt%) [13].

1.5 Bond strength:

Shear bond testing is done under universal testing machine with the metal blade on a standardised crosshead speed till the resin bond failure occurs. This debonding force is measured in newton which is later converted to megapascals [14]. Scribante.A et.al concluded in his study that the shear bond strength is the most important criterion for successful bonding of an orthodontic bracket because it needs to sustain a wide variety of forces during orthodontic treatment [15]. Reynolds suggested that the minimum acceptable shear bond strength in orthodontic clinic ranges from 5.9 to 7.8 MPa [16]. According to Sen Yilmaz B et.al,

the bond strength obtained by comparing three primer incorporated adhesive (Group 1:GC Ortho Connect, Group 2: Biofix, Group 3: Orthocem) with self-etching primer + adhesive (Group 4: Transbond Plus) and conventional adhesive (Group 5: Transbond XT) showed superior results in Group 5 which is conventional adhesive group (Mean 14.01 MPa) followed by GC Ortho Connect (Mean 11.86 MPa). The other groups showed significantly lower results [11]. In a study conducted by Shapinko Y et.al, bond strength was compared between conventional adhesive and GC Ortho Connect self priming adhesive. Group I : Transbond XT, Group II: GC Ortho Connect SPA, Group III: GC Ortho Connect with primer. Mean shear bond strength obtained were Group I 7.25 ± 3.18 MPa, Group II 6.57 ± 2.75 MPa and Group III 7.33 ± 3.06 MPa which was not statistically significant [17]. Joseph R et.al evaluated and compared the shear bond strength between conventional (Enlight LV, Ormco) self etching (Transbond Plus SEP) and primer incorporated orthodontic adhesive (GC Ortho Connect) and found the results in contrast with the above studies. The self priming adhesive GC Ortho Connect showed the highest mean bond strength of 12.68 ± 6.25 MPa followed by control group Enlight LV 11.60 ± 2.95 MPa and self etching adhesive showed the lowest values of 9.44 ± 4.46 MPa [18]. Shaik MS investigated the shear bond strength of various orthodontic adhesives like Transbond XT, Heliosit, Rely-a-bond, Enlight and Concise. The results showed: Transbond XT (14.30 ± 4.35 MPa) > Enlight (13.92 ± 3.92 MPa) > Heliosit (11.4 ± 3.87 MPa) > Concise (10.78 ± 4.16 MPa) > Rely-a-bond (6.78 ± 1.83 MPa). Heliosit showed clinically significant bond strength [12]. Similar results were achieved in a study by Ibadullah et.al where conventional orthodontic adhesive Transbond XT was compared with Heliosit and results showed Transbond XT (25.5 MPa) showed improved mean shear bond strength compared to Heliosit (10.54 MPa) but both had higher values than the recommended values of Reynolds concluding that Heliosit is clinically as effective as the conventional orthodontic adhesive [19]. No primer adhesive Heliosit (10.45 MPa) had the lowest bond strength compared to the conventional adhesive Transbond XT with primer application (16.77 MPa) and without primer application (12.67 MPa) in a study conducted by Tutika K et.al [20]. Biofix, a self priming orthodontic adhesive was compared with the conventional light cure Transbond XT and conventional self cure Unite 3M orthodontic adhesive. The mean shear bond strength was lowest for the Biofix adhesive (9.3050 MPa) but showed no statistically difference with the bond strength of self cure adhesive (9.8985 MPa). The highest shear bond strength was achieved with Transbond XT [21].

1.6 ARI score evaluation:

An useful indicator for assessing the strength of the bond with the enamel surface was the adhesive remnant index (ARI). It was quantified based on the amount of residual adhesive retained on the enamel surface after debracketing. The more the amount of residual adhesive on tooth surface, more the strength of the bond [22]. This index system was developed by Artun and Bergland which was scored accordingly: Score 0 = No adhesive left on the tooth. Score 1 = Less than half of the adhesive left on the tooth. Score 2 = More than half of the adhesive left on the tooth. Score 3 = All adhesive left on the tooth, with distinct impression of the bracket mesh [23]. ARI scores and shear bond strength didn't show parallelism depicting higher ARI scores in GC Ortho Connect self priming adhesive group and self etching group compared to the conventional adhesive. Biofix and Orthocem showed ARI scores lesser than 1 indicating <50% adhesive left on tooth surface [11].

Similarly ARI scores were not in harmony with the shear bond strength in another study done by Shapinko et.al showing 50% adhesive left in self priming adhesive group (GC Ortho Connect) which showed the lowest shear bond strength and more of the resin remnants were left on the bracket base indicating a compromised bond in GC Ortho Connect with primer application which showed the highest bond strength [16]. In a study conducted by Joseph R et.al, ARI Score of 2 [50% or more adhesive left on tooth surface] was predominantly distributed between the conventional (Enlight LV), self priming (GC Ortho Connect) and self etching (Transbond Plus SEP) orthodontic adhesive while Score 1 and 3 were equally distributed in all the group [17].

In contrast to the above studies, ARI scores was in accordance with the shear bond strength in a study done by Tutika K et.al. Higher ARI score 3 was more frequently distributed in conventional Transbond XT group (48%) which showed highest bond strength followed by ARI score of 2 more frequently distributed in Heliosit self priming adhesive group (52%) and ARI score of 0 more frequently distributed in Trandbond adhesive without primer group (36%) which showed the lowest shear bond strength [19].

1.7 SEM analysis:

The penetration of the resin into the enamel surface occurs at different level of depths thus resulting in varying amount of residual adhesive retained in the enamel surface after debonding [24]. Scanning electron microscopy has been used in various studies for analysing the debonded enamel-adhesive interface. Pillai et.al evaluated the resin tag penetration of self priming orthodontic adhesive and compared it with the conventional and self cure orthodontic adhesive. The depth of penetration by self priming adhesive (Biofix) was 3-9 µm which was comparable to that of the self cure adhesive (Unite) which was 3-8 µm. Conventional adhesive (Transbond XT) showed higher level of penetration as 10-20 µm [21]. Regular debonding with clean-up hardly ever removes more than 5 µm, and there is a chance that resin tags will continue to be present in the enamel after debonding [25]. Remaining resin trapped after debonding leads to difficulty in clean up and as well as it becomes discoloured resulting in esthetic issues. Thus an orthodontic adhesive should benefit with sufficient bond strength and little resin penetration [26].

Summary:

- Shear bond strength of self priming orthodontic adhesive was clinically acceptable for an effective bonding
- The conventional orthodontic adhesive showed higher values of SBS compared to self priming orthodontic adhesive
- The ARI scores of self priming adhesives concluded that the clean up procedure of residual adhesive left on the tooth surface is less difficult compared to the conventional orthodontic adhesive.

• Scanning electron microscopy showed sufficient resin penetration by self priming adhesive thereby reducing the time and difficulty for clean up

Fig 1: Heliosit self priming orthodontic adhesive

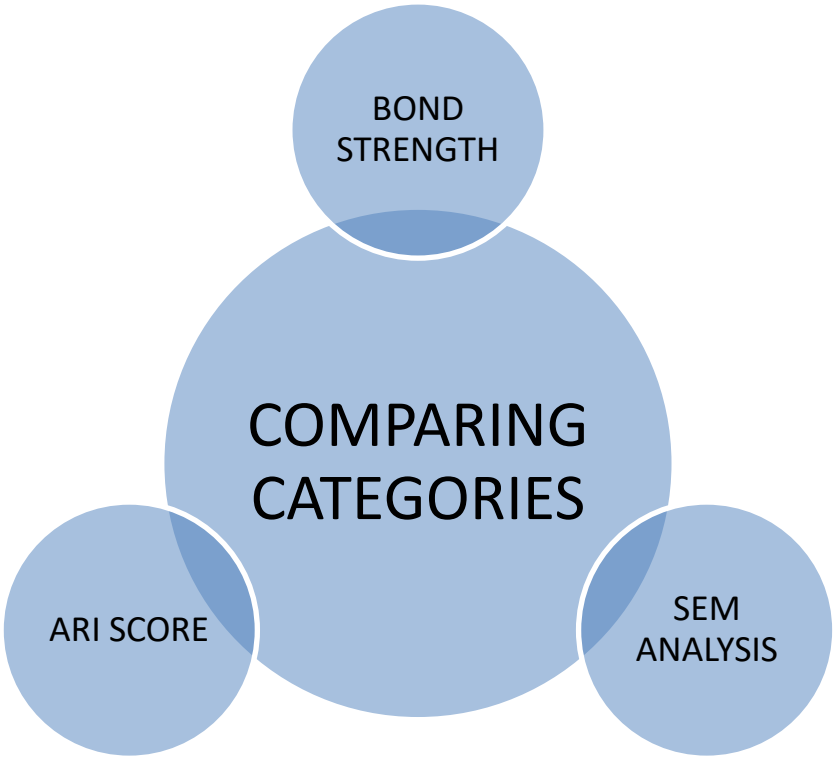

Fig 2: Comparing categories

4. Conclusions

This review concludes that since the self-priming adhesive showed clinically acceptable shear bond strength with less difficulty in clean up and reduced the chair time thereby preventing moisture contamination and bond failure, it could be used as an alternative for conventional orthodontic adhesive. This could improvise the treatment outcome. Invivo studies on self-priming adhesives are limited. Thus in future, we suggest that these findings should be corroborated by clinical studies for obtaining accurate results for benefiting with this new adhesive system.

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